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DIODE STEP STRESS TESTING PROGRAM

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NAS8-31944

FINAL REPORT
FOR
JANTX1N4570A

FEBRUARY 1979

Prepared
For

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FOREWORD

This is a summary of the work performed on NASA Contract NAS8-31944. The investigation was conducted for the National Aeronautics and Space Administration, George C. Marshall Space Flight Center, Huntsville, Alabama. The Contracting Officer's Technical Representative was Mr. F. Villella.

The short-term objective of this preliminary study of transistors, diodes, and FETS was to evaluate the reliability of these discrete devices, from different manufacturers, when subjected to power and temperature step stress tests.

The long-term objective is to gain more knowledge of accelerated stress testing for use in future testing of varieties of discrete devices, as well as to determine which type of stress should be applied to a particular type of device or design.



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1.0 INTRODUCTION

DCA Reliability Laboratory, under Contract NAS8-31944 for NASA/Marshall Space Flight Center, has compiled data for the purpose of evaluating the effect of power/temperature step stress when applied to a variety of semiconductor devices. This report covers the zener diode JANTX1N4570A manufactured by Siemens and Motorola.

A total of 48 samples from each manufacturer was submitted to the process outlined in Table 1. In addition, two control sample units were maintained for verification of the electrical parametric testing.

2.0 TEST REQUIREMENTS

2.1 Electrical

All test samples were subjected to the electrical tests outlined in Table 2 after completing the prior power/temperature step stress point. These tests were performed using the Fairchild Model 600 high-speed computer-controlled tester. Additional bench testing was also required on the devices.

2.2 Stress Circuit

The test circuit shown in Figure 1 was used to power all of the test devices during the power/temperature stress conditions. The voltage was set by V_Z and the current was varied in order to comply with the specified power rating for this device. At least one of the devices was subjected to maximum rated power (MRP). All remaining devices were subjected to no less than



90% of MRP. See Figure 1 for load resistance values and voltages.

2.3 Group I - Power Stress

Thirty-two units, 16 from each manufacturer, were submitted to the Power Stress Process. The diodes were stressed in 500-hour steps at 50, 100, 125, 150 and 175 percent of maximum rated power (MRP) for 2500 hours or until 50% or more of the devices in a sample lot failed.* Electrical measurements were performed on all specified electrical parameters after each power step. See Table 1.

2.4 Group II - Temperature Stress I

Thirty-two units, 16 from each manufacturer, were submitted to the Temperature Stress I Process. Group II was subjected to 1600 hours of stress at maximum rated power in increments of 160 hours. The temperature was increased in steps of 25°C, commencing at 75°C and terminating at 300°C or until 50% or more of the devices failed.* Electrical measurements were performed on all specified electrical parameters after each temperature step. See Table 1.

2.5 Group III - Temperature Stress II

Thirty-two units, 16 from each manufacturer, were submitted to the Temperature Stress II Process. Group III was subjected to 112 hours of stress at maximum rated power in increments of 16 hours. The temperature was increased in steps of 25°C, commencing at 150°C and terminating at 300°C or until 50% or more of the devices in a sample lot failed.* Electrical measurements were

* Conditions for failure:

- A) Open or short
- B) Leakage exceeds the maximum limit by 100 times
- C) Other parameters exceed MIL limits by 50% or more.



performed on all specified electrical parameters after each temperature step. See Table 1.

3.0 DISCUSSION OF TEST RESULTS

3.1 Group I - Power Stress

3.1.1 Siemens. The Siemens sample lot completed the entire 2500-hour Group I Testing with four catastrophic failures. The first three failures occurred 250 hours into the 175% MRP step. Serial numbers 9696, 9697, and 9704 failed the minimum B_V limit. The last failure occurred 500 hours into the 175% MRP step. Serial number 9699 failed the minimum B_V limit. Serial number 9703 was lost from this lot 50 hours into the 100% MRP step. Typical characteristics of this sample lot's performance were:

- 1) The mean value for B_V changed .056V from an initial mean of 6.384V to a final mean of 6.328V.

The control units for this sample lot remained constant throughout the entire Group I Testing.

3.1.2 Motorola. The Motorola sample lot completed 2150 hours of Group I Testing before the lot was stopped because 50% of the devices failed. The first failure occurred 150 hours into the 125% MRP step. Serial number 9750 failed the maximum B_V limit. The next failure occurred 250 hours into the 150% MRP step. Serial number 9761 failed the minimum B_V limit. The next failure occurred 25 hours into the 175% MRP step. Serial number 9749 failed the minimum B_V limit. The last five failures occurred 50 hours into the 175% MRP step. Serial numbers 9746, 9747, 9758, and 9760 failed the minimum



B_V limit. Serial number 9757 failed the maximum B_V limit. Typical characteristics of this sample lot's performance were:

- 1) The mean value for B_V changed 1.851V from an initial mean of 6.239V to a final mean of 4.388V.

The control units for this sample lot remained constant throughout the entire Group I Testing.

3.1.3 Statistical Summary - Group I

Table 4 outlines the results of Group I - Power Stress Process for the electrical parameter and all measurement points for both Siemens and Motorola.

3.2 Group II - Temperature Stress I

- 3.2.1 Siemens. The Siemens sample lot completed 1440 hours of Group II Testing before the lot was stopped because more than 50% of the devices failed. The first five failures occurred 160 hours into the 225°C-temperature step. Serial numbers 9716 and 9720 failed the minimum B_V limit. Serial numbers 9714, 9715, and 9718 failed the maximum B_V limit. The next three failures occurred 160 hours into the 250°C-temperature step. Serial numbers 9709, 9711, and 9717 failed the minimum B_V limit. The last five failures occurred 160 hours into the 275°C-temperature step. Serial numbers 9708, 9712, 9713, 9719, and 9721 failed the minimum B_V limit. Serial number 9723 was removed from the Group II Testing 160 hours into the 200°C-temperature step as a MIL-STD-19500 limit failure. Serial number 9722 was removed from the Group II Testing 160 hours into the 225°C-temperature step as a MIL-STD-19500 limit failure.



Typical characteristics of this sample lot's performance were:

- 1) The mean value for B_V changed .764V from an initial mean of 6.221V to a final mean of 5.457V.

The control units for this sample lot remained constant throughout the entire Group II Testing.

3.2.2 Motorola. The Motorola sample lot completed 1120 hours of Group II Testing before the lot was stopped because more than 50% of the devices failed. The first failure occurred 160 hours into the 100°C-temperature step. Serial number 9771 failed the minimum B_V limit. The next failure occurred 160 hours into the 125°C-temperature step. Serial number 9763 failed the maximum B_V limit. The next failure occurred 160 hours into the 150°C-temperature step. Serial number 9774 failed the minimum B_V limit. The next two failures occurred 160 hours into the 175°C-temperature step. Serial numbers 9770 and 9776 failed the minimum B_V limit. The next failure occurred 160 hours into the 200°C-temperature step. Serial number 9775 failed the maximum B_V limit. The last four failures occurred 160 hours into the 225°C-temperature step. Serial number 9764 failed the minimum B_V limit. Serial numbers 9768, 9769, and 9777 failed the maximum B_V limit. Serial number 9767 was also removed from the Group II Testing at this point as a MIL-STD-19500 limit failure. Typical characteristics of this sample lot's performance were:

- 1) The mean value for B_V changed .764V from an initial mean of 6.221V to a final mean of 5.457V.

The control units for this sample lot remained constant throughout the entire Group II Testing.



3.2.3 Statistical Summary - Group II

Table 5 outlines the results of Group II - Temperature Stress I Testing for the electrical parameter and all of the measurement points pertaining to both Siemens and Motorola.

3.3 Group III - Temperature Stress II

3.3.1 Siemens. The Siemens sample lot completed a total of 96 hours before the lot was stopped because more than 50% of the devices failed. The first failure occurred 16 hours into the 225°C-temperature step. Serial number 9739 failed the minimum B_V limit. The next three failures occurred 16 hours into the 250°C-temperature step. Serial numbers 9724, 9734, and 9737 failed the minimum B_V limit. The last five failures occurred 16 hours into the 275°C-temperature step. Serial numbers 9730, 9732, 9733, 9736, and 9738 failed the minimum B_V limit. Typical characteristics of this sample lot's performance were:

- 1) The mean value for B_V changed 2.384V from an initial mean of 6.383V to a final mean of 3.999V.

The control units for this sample lot remained constant throughout the entire Group III Testing.

3.3.2 Motorola. The Motorola sample lot completed 96 hours of Group III Testing before the lot was stopped because of four catastrophic failures and four MIL-STD-19500 limit failures. The first two catastrophic failures occurred 16 hours into the 200°C-temperature step. Serial numbers 9783 and 9787 failed the minimum B_V limit. The first two MIL-STD-19500 limit failures pulled occurred 16 hours into the 225°C-temperature



step. Serial numbers 9778 and 9779 were the devices pulled at this point. The last two catastrophic failures occurred 16 hours into the 275°C-temperature step. Serial numbers 9791 and 9790 failed the minimum B_V limit. The last two MIL-STD-19500 limit failures were also removed from the testing at this point (S/N 9786 and 9793). Typical characteristics of this sample lot's performance were:

- 1) The mean value for B_V changed .983V from an initial mean of 6.232V to a final mean of 5.249V.

The control units for this sample lot remained constant throughout the entire Group III Testing.

3.3.3 Statistical Summary - Group III

Table 6 outlines the results of Group III - Temperature Stress II Testing for the electrical parameter and all of the measurement points pertaining to both Siemens and Motorola.

4.0 FINAL DATA SUMMARY

Table 7 statistically summarizes the change in the mean value from the zero-hour data to the final data. The graphs of Figures 2 and 4 plot the cumulative percent failures versus the temperature stress level for Group II - Temperature Stress I, and Group III - Temperature Stress II. The graphs of Figures 3 and 5 plot the time step for Group II (160 hours) and Group III (16 hours) versus the temperatures T_1 and T_2 calculated from Figures 2 and 4. Tables 8 and 9 summarize the failures encountered for all three stress groups. The failures are separated into two categories: catastrophic



failures in Table 8 and parametric failures in Table 9. The data from Table 8 was used as a source for the graphs in Figures 2 and 4. Figures 2 and 4 were used as a source for the graphs in Fig. 3 and 5 respectively. Junction temperature is plotted on an inverse hyperbolic scale.

5.0 CONCLUSIONS

Of the three stress groups, Group II proved to be the most detrimental to both manufacturers. Many of the Siemens diodes had hard breakdowns which did not change when measured at any current between one microamp and one milliamp. The fact that they met their breakdown limits at earlier measurement points suggests that there were originally junction defects present which caused the devices to operate at a lower voltage. These atomic level defects were "burned out" of the dice, thus allowing the true breakdowns to appear.

The Motorola samples each contain two dice in series, presumably as a means of tailoring the breakdown voltage to the desired value. When measured at low and high currents (1.0 μ A and 1.0mA) two distinct breakdowns can be seen. As with the Siemens devices, the change to higher breakdowns after some hundreds of hours of stress can be explained by the burning out of diffusion spikes from the junction, again allowing the true breakdowns to appear.

A plot showing cumulative failure distribution for Groups II and III was drawn for the Siemens and Motorola sample lots (Figures 2 and 3 and 4 and 5 respectively).



Figures 2 and 3 display the data for the Siemens sample lot used to calculate an activation energy of 2.20eV. Figures 4 and 5 display the data for the Motorola sample lot used to calculate an activation energy of .73eV.

A broken circle around a marked point on the graph indicates a freak failure not calculated as part of the regression line. A solid circle around a marked point indicates an isolated main failure point. The regression line was calculated using the least squares method.

Because of visual defects caused by the extreme heat of the stress tests, serial numbers 9737, 9738, and 9739 were not calculated as part of the regression line.

The activation energy was calculated from the formula:

$$E = \left[\ln \left(\frac{t_1}{t_2} \right) \right] \left[\frac{8.63 \times 10^{-5} \text{ eV/}^\circ\text{K}}{\left(\frac{1}{T_1 + 273} \right) - \left(\frac{1}{T_2 + 273} \right)} \right] \text{ eV}$$

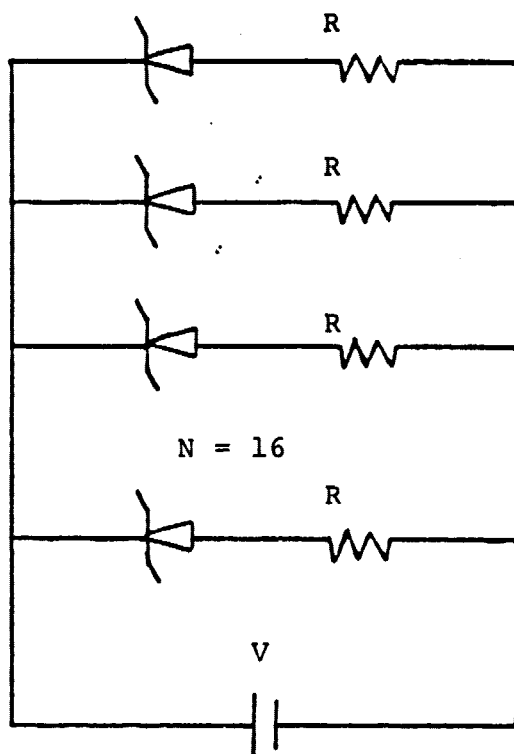
Where: t_1 = step of Group II - Temp Stress I = 160 hrs.
 t_2 = step of Group III - Temp Stress II = 16 hrs.
 T_1 = temperature in $^\circ\text{C}$ of 16% failure for Group II.
 T_2 = temperature in $^\circ\text{C}$ of 16% failure for Group III.



JANTX1N4570A

FIGURE 1

ZENER DIODES



$$R = VZ \div 1.75 I_{Z_{MAX}} \pm 50\%$$

$$P_d = VZ^2 \div R$$

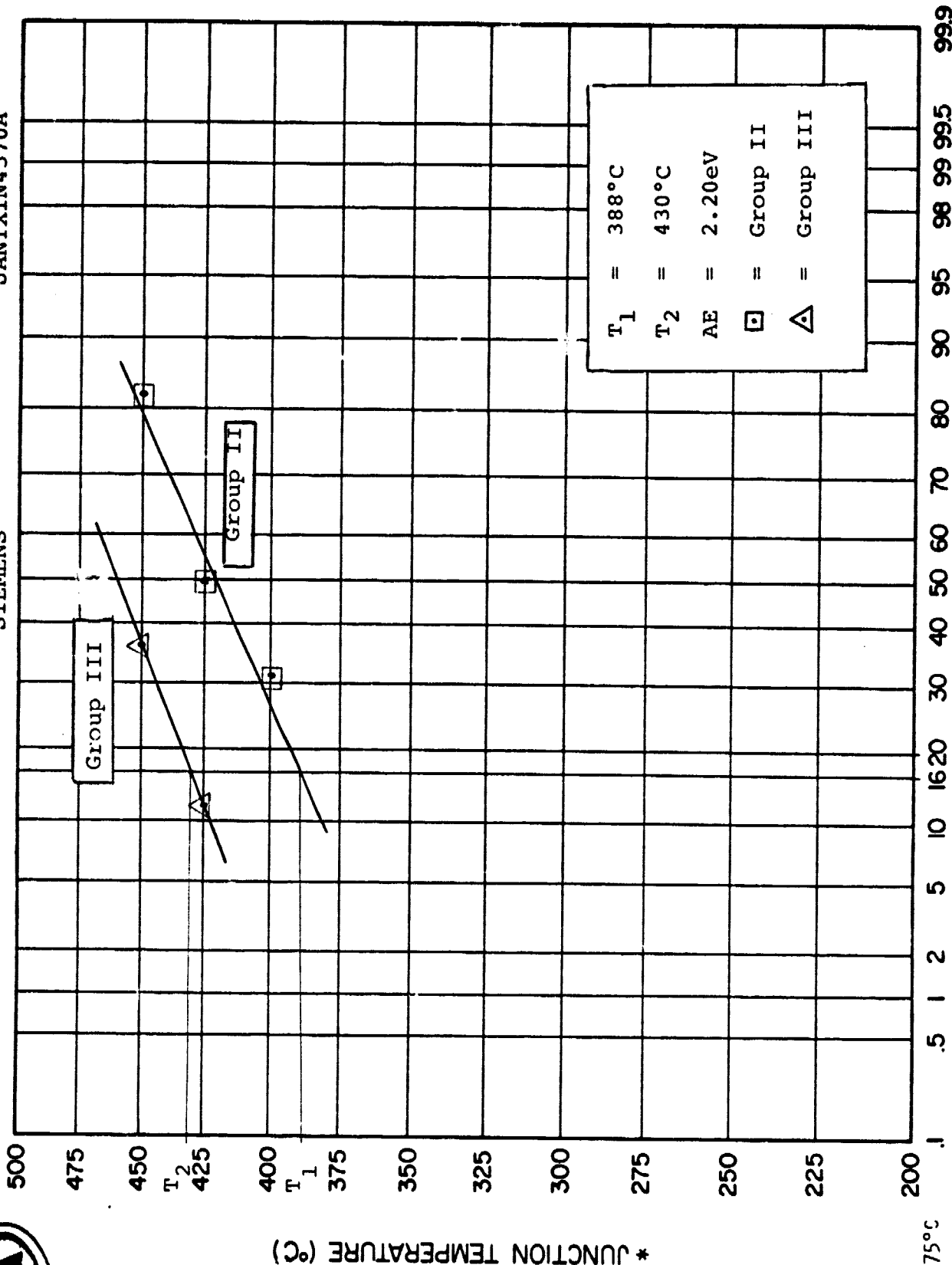
Power/Temperature Stress Circuit
for JANTX1N4570A



JANTX1N4570A

SIEMENS

JANTX1N4570A



*NOTE

$$T_J \approx T_A + 175^\circ\text{C}$$

CUMULATIVE PERCENT FAILURES (%)
FIGURE 2

Cumulative Percent Failures Versus Junction Temperature, Siemens



* JUNCTION TEMPERATURE (°C)

*NOTE

$$T_J \approx T_A + 175^\circ\text{C}$$

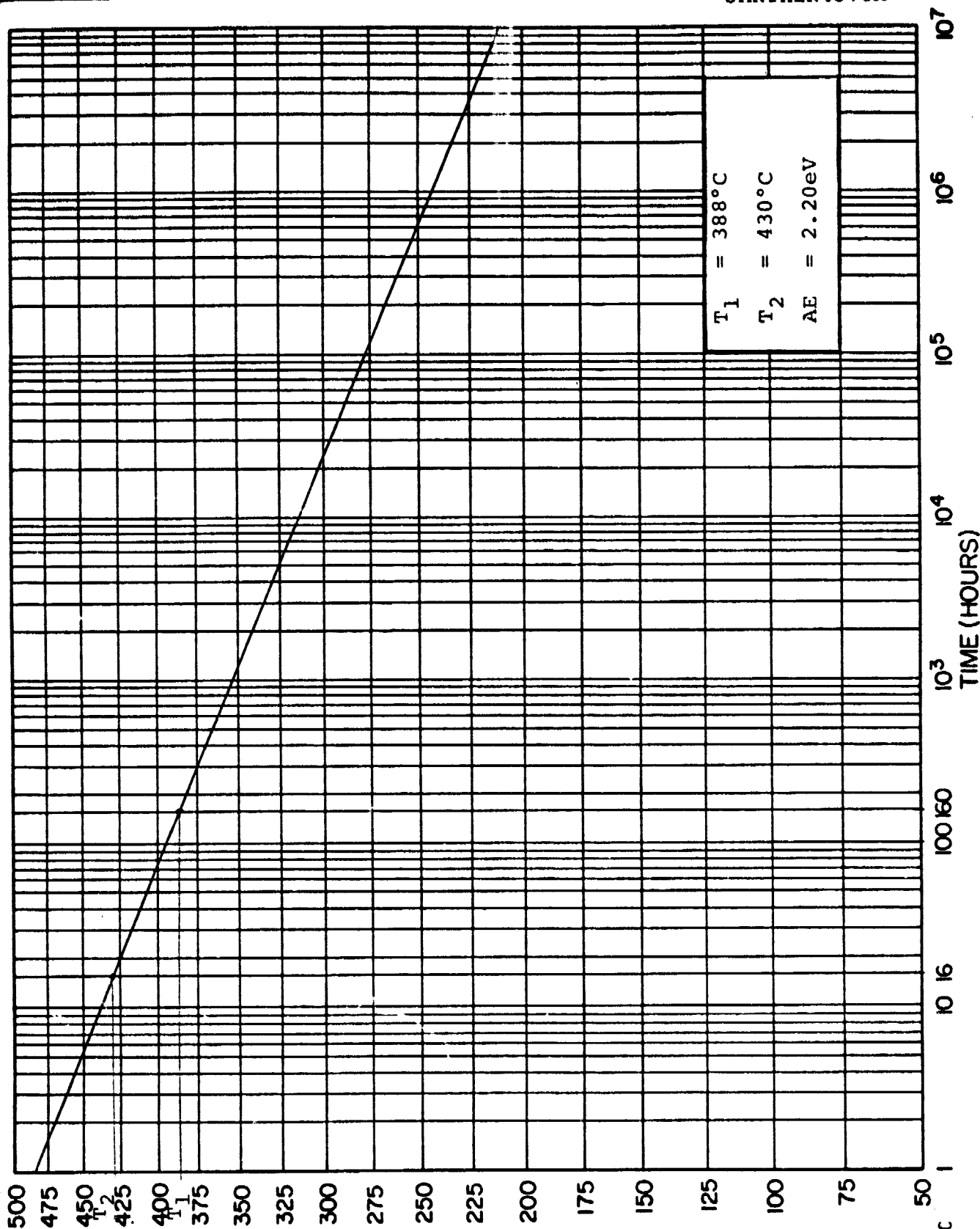


FIGURE 3

Time Steps Versus Junction Temperature, Siemens

JANTX1N4570A

TX: 570

5.000000



MOTOROLA

JANTX1N4570A

JANTX1N4570A

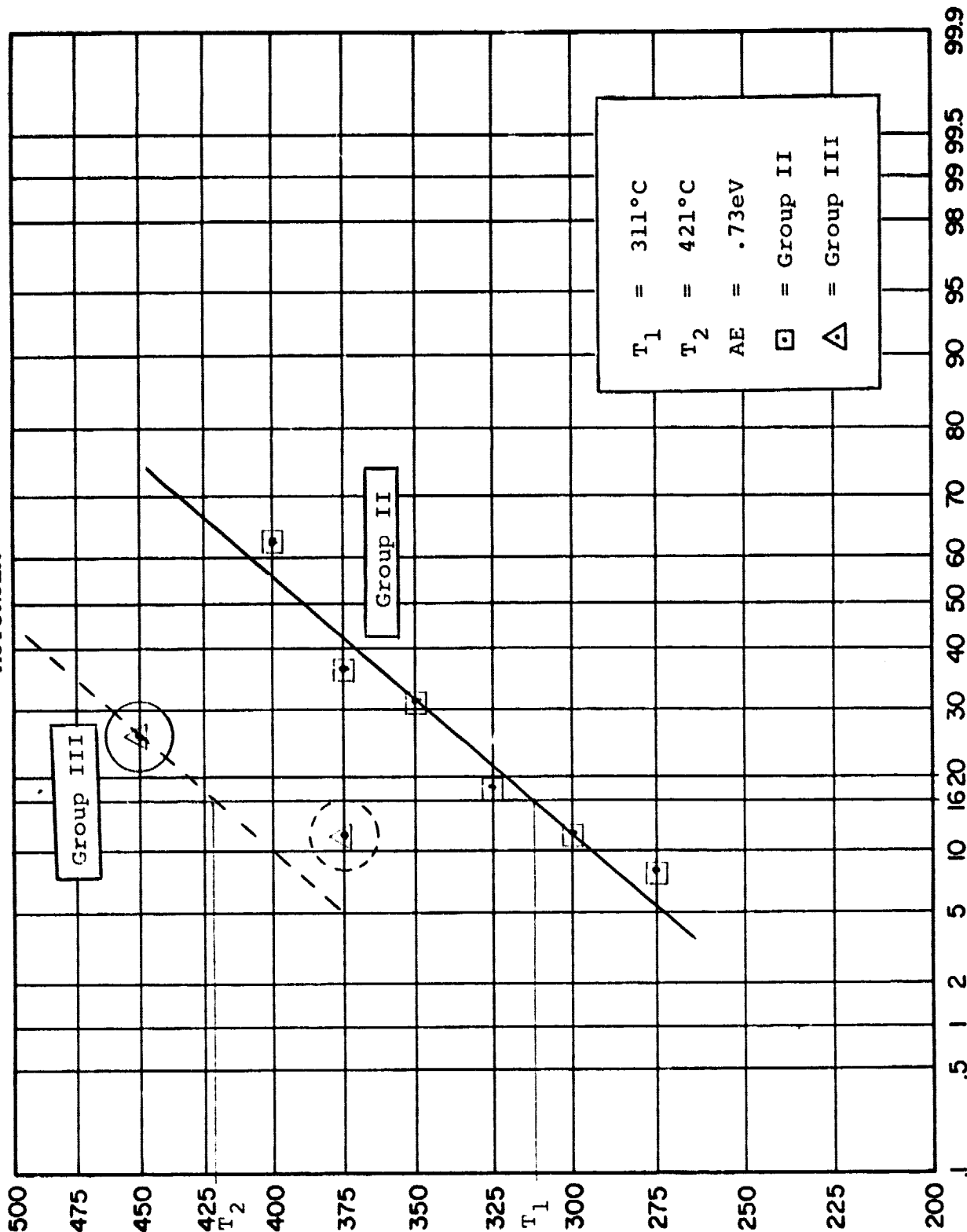


FIGURE 4
Cumulative Percent Failures Versus Junction Temperature, Motorola

*NOTE

$$T_J \approx T_A + 175^{\circ}\text{C}$$

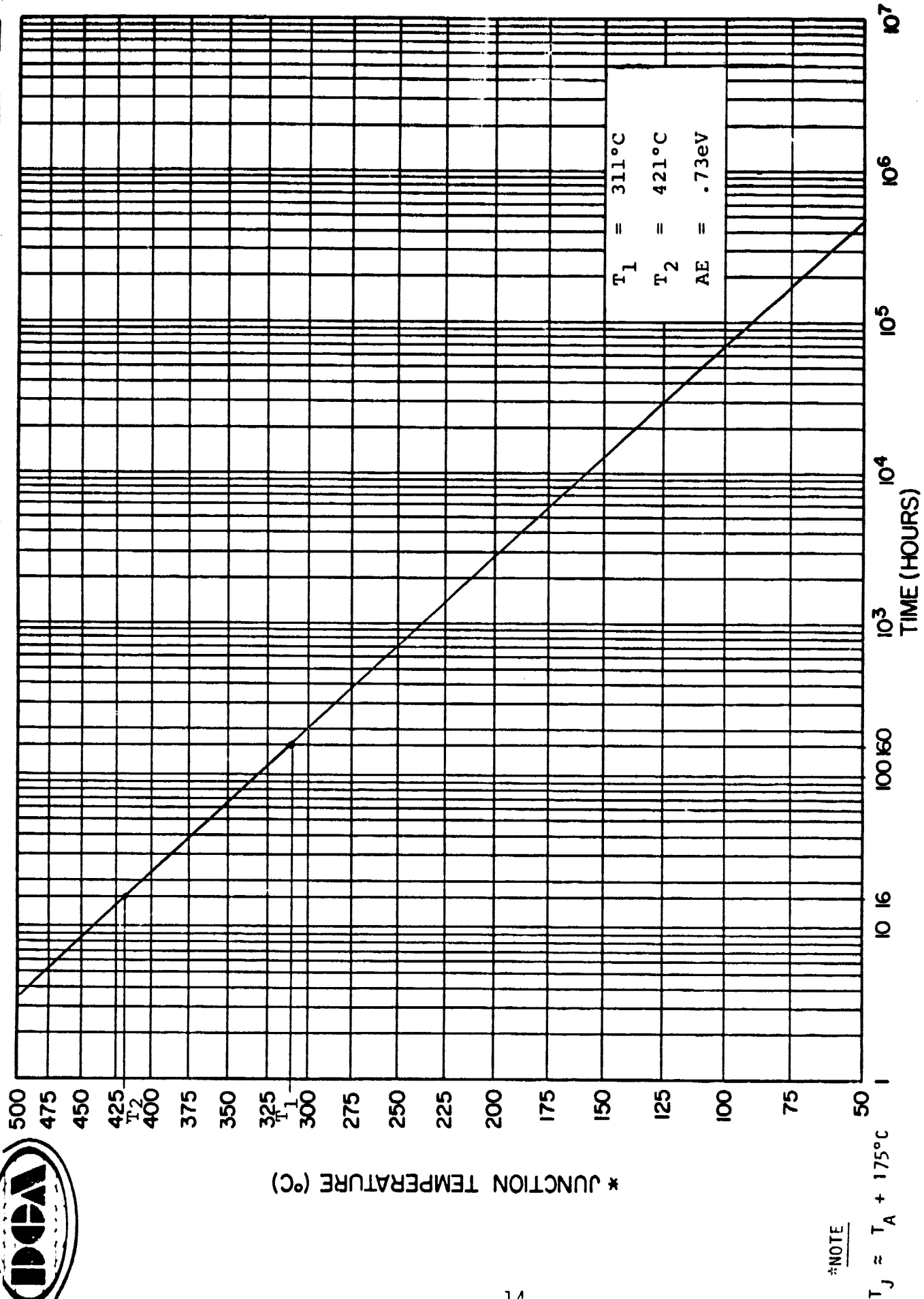
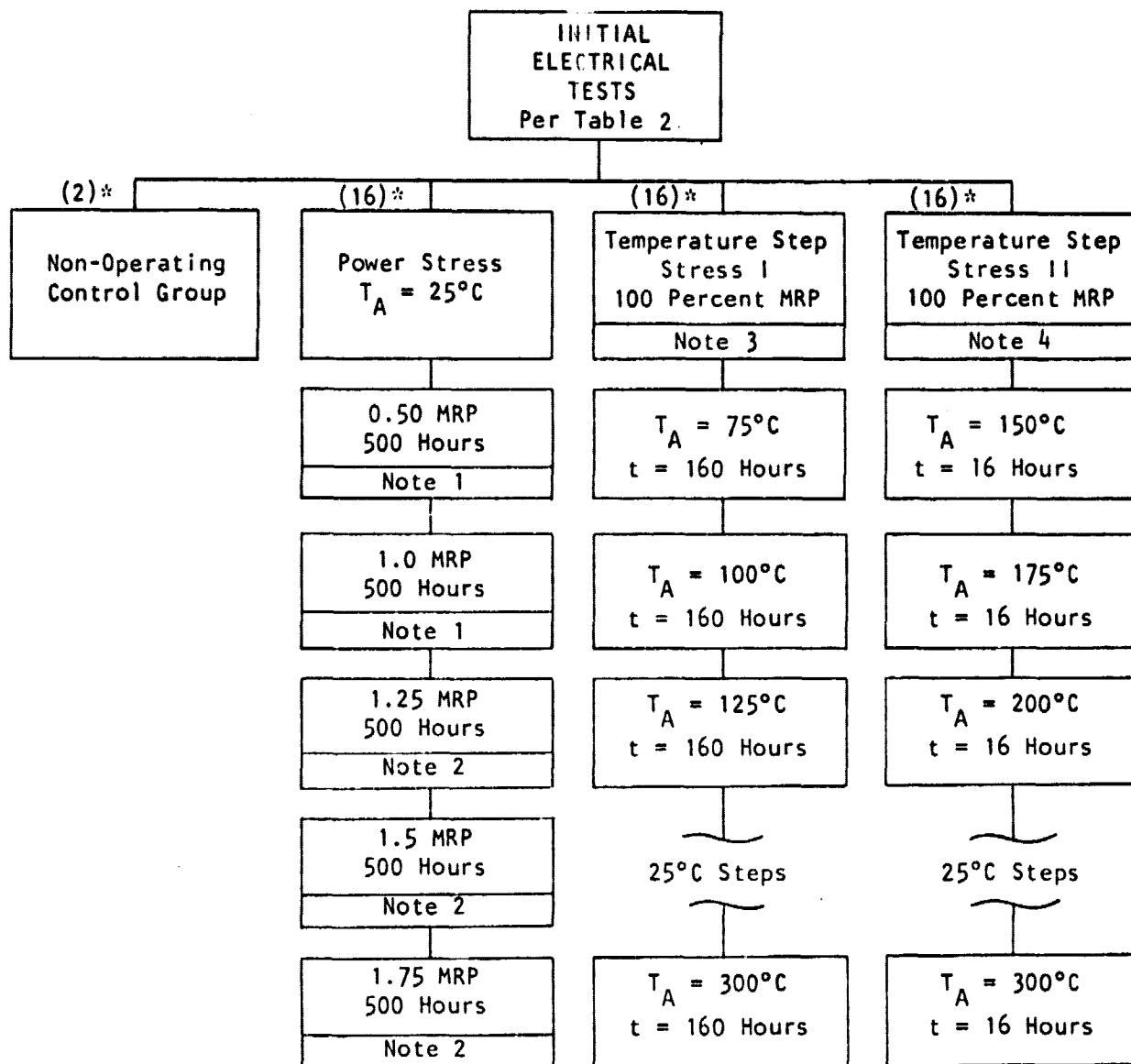


TABLE 1
TEST FLOW DIAGRAM

*Quantity per manufacturer (Siemens and Motorola)

NOTES:

- 1) Electrical measurements per Table 2 were made at 50, 150, 250 and 500 hours.
- 2) Electrical measurements per Table 2 were made at 10, 25, 50, 150, 250 and 500 hours.
- 3) Electrical measurements per Table 2 were made at the end of each 160 hours.
- 4) Electrical measurements per Table 2 were made at the end of each 16 hours.



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JANTX1N4570A

TABLE 2
PARAMETERS AND TEST CONDITIONS

PARAMETER	CONDITIONS	SPEC LIMITS		CAT. LIMITS *		UNITS
		MIN	MAX	MIN	MAX	
B_V	@ $I_Z = 1.0^{+0.01}_{-0.01} \text{mA}$	6.08	6.72	3.04	10.08	V

NOTES: * In addition, any open or short shall be considered catastrophic.

TABLE 3
POWER STRESS BURN-IN CONDITIONS

$V_Z = 6.4\text{V}$	
$I_Z =$	% P_D
31.0mA	50
62.0mA	100
77.5mA	125
93.0mA	150
108.5mA	175



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NOTE
FOR TABLES
4 THROUGH 7

The minimum/maximum initial and final data generally have an absolute accuracy of $\pm 1\%$ of the reading and $\pm$ one digit except for readings greater than 9.99mA which have an absolute accuracy of $\pm 2\%$ of the reading and $\pm$ one digit. The data also has a resolution for four digits. The standard deviations, means, delta means, and average means are, therefore, valid indicators of trends over time and temperature, excepting the minor statistical computer error of supplying a constant number of significant digits.



GROUP I - POWER STRESS DATA SUMMARY

TABLE 4

PARAMETER	$B_V = 6.08 \text{ (MIN) } 6.72 \text{ (MAX)}$				
CONDITIONS AND LIMIT	@ $I_Z = 1.0 \pm .01 \text{ mA}$				
IDENTIFICATION	SIEMENS	MOTOROLA			
INITIAL DATA					
MIN VALUE	6.158V	6.179V			
MAX VALUE	6.458V	6.279V			
MEAN	6.384V	6.239V			
STD DEV	.084V	.027V			
INTERIM DATA					
POWER 50 TO 125% Δ MEAN VALUE					
50% POWER					
50 Hours	-.003V	-.002V			
150 Hours	-.003V	-.000V			
250 Hours	-.004V	-.002V			
500 Hours	-.004V	-.001V			
100% POWER					
550 Hours	-.003V	+.001V			
650 Hours	+.001V	-.001V			
750 Hours	+.005V	-.003V			
1000 Hours	+.005V	-.000V			
125% POWER					
1010 Hours	+.006V	+.005V			
1025 Hours	+.005V	-.001V			
1050 Hours	+.005V	+.001V			
1150 Hours	+.010V	+.002V			
1250 Hours	+.010V	-.001V			
1500 Hours	+.011V	-.000V			

(continued on second sheet)



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TABLE 4 (Cont'd)
GROUP I - POWER STRESS DATA SUMMARY

Page 2 of 2

PARAMETER		$B_V = 6.08 \text{ (MIN)}$ 6.72 (MAX)			
CONDITIONS AND LIMITS		$@ I_Z = 1.0^{+0.01} \text{ mA}$			
IDENTIFICATION		SIEMENS		MOTOROLA	
INITIAL DATA					
MIN VALUE		6.158V		6.179V	
MAX VALUE		6.458V		6.279V	
MEAN		6.384V		6.239V	
STD DEV		.084V		.027V	
INTERIM DATA					
POWER 150 TO 175%					
Δ MEAN VALUE					
150% POWER					
1510 Hours		+.010V		-.000V	
1525 Hours		+.007V		+.001V	
1550 Hours		+.007V		+.002V	
1650 Hours		+.008V		+.003V	
1750 Hours		+.008V		*-.301V	
2000 Hours		+.010V		+.008V	
175% POWER					
2010 Hours		+.006V		+.003V	
2025 Hours		+.005V		*-.230V	
2050 Hours		+.005V		+.010V	
2150 Hours		-.088V		*-1.851V	

2250 Hours		*-1.256V		Job Stopped	
2500 Hours		*-0.056V			
FINAL DATA					
MIN VALUE		2.966V		.096V	
MAX VALUE		10.310V		6.287V	
MEAN		6.328V		4.388V	
STD DEV		1.485V		2.521V	

*NOTE: Catastrophic Rejects removed from data.

GROUP	II	TEMP STRESS	I	DATA SUMMARY	(160 Hours)
-------	----	-------------	---	--------------	-------------

PARAMETERS		B _V =6.08V (MIN) 6.72V (MAX)	
CONDITIONS AND LIMITS		@ I _Z =1.0 ⁺ .01mA	
IDENTIFICATION		SIEMENS	MOTORLOA
INITIAL DATA			
MIN VALUE		6.199V	6.181V
MAX VALUE		6.450V	6.274V
MEAN		6.384V	6.221V
STD DEV		.060V	.029V
INTERIM DATA (INITIAL TO FINAL)			
Δ MEAN VALUE			
Total Hours	Temp (T _A)		
160	75°C		
320	100°C	-.001V	
480	125°C	-.000V	
640	150°C	+.005V	
800	175°C	+.010V	
960	200°C	+.009V	
1120	225°C	+.018V	
		+.011V	
1280	250°C	*-1.922V	
1440	275°C	*-5.110V	
1600	300°C	Job Stopped	
		Job Stopped	
FINAL DATA			
FINAL TEMP		275°C	
MIN VALUE		.405V	
MAX VALUE		6.267V	
MEAN		1.274V	
STD DEV		1.779V	

*NOTE: CATASTROPHIC REJECTS REMOVED FROM DATA

TABLE 6
GROUP III TEMP STRESS II DATA SUMMARY (16 Hours)

PARAMETERS	B _V = 6.08V (MIN) 6.72V (MAX) @ I _Z = 1.0 ± 0.01mA					
CONDITIONS AND LIMITS						
IDENTIFICATION	SIEMENS	MOTOROLA				
INITIAL DATA						
MIN VALUE	6.137V	6.172V				
MAX VALUE	6.448V	6.436V				
MEAN	6.383V	6.232V				
STD DEV	.084V	.063V				
INTERIM DATA (INITIAL TO FINAL)						
Δ MEAN VALUE						
Total Hours						
Temp (T _A)						
16	+ .008V	+ .002V				
32	+ .011V	+ .005V				
48	+ .012V	* - .698V				
64	* - .343V	+ .014V				
80	* - 1.164V	- .708V				
96	* - 2.384V	* - .983V				
112	Job Stopped		Job Stopped			
300°C						
FINAL DATA						
FINAL TEMP	275°C	275°C				
MIN VALUE	.226V	.632V				
MAX VALUE	6.459V	6.290V				
MEAN	3.999V	5.249V				
STD DEV	2.879V	1.895V				

* NOTE: CATASTROPHIC REJECTS REMOVED FROM DATA



TABLE 7
FINAL DATA SUMMARY

PARAMETER	SPECIFICATIONS LIMIT		U N I T S	MEAN INT. DATA	AVERAGE Δ IN MEAN VALUE						
					POWER STRESS		TEMPERATURE STRESS I		TEMPERATURE STRESS II		
	MIN	MAX									SIEMENS
B _V	6.08	6.72	V		* -.04973	* -.09821	* -.77556	* -.38914	* -.64333	* -.39467	

* NOTE: Catastrophic reject(s) removed from data.

TABLE B STEP STRESS CATASTROPHIC FAILURE SUMMARY JAN TXJN4570A

GROUP I POWER STRESS

TEST STEP	MFR A		MFR B	
	QTY.	NOTE	QTY.	NOTE
50% 50 hr.	0	-	0	-
100 hr.	0	-	0	-
100 hr.	0	-	0	-
250 hr.	0	-	0	-
100% 50 hr.	0	-	0	-
100 hr.	0	-	0	-
100 hr.	0	-	0	-
250 hr.	0	-	0	-
125% 10 hr.	0	-	0	-
15 hr.	0	-	0	-
25 hr.	0	-	0	-
100 hr.	0	-	1	B
100 hr.	0	-	0	-
250 hr.	0	-	0	-
150% 10 hr.	0	-	0	-
15 hr.	0	-	0	-
25 hr.	0	-	0	-
100 hr.	0	-	0	-
100 hr.	0	-	1	A
250 hr.	0	-	0	-
175% 10 hr.	0	-	0	-
15 hr.	0	-	1	A
25 hr.	0	-	4	A
100 hr.	0	-	Job Stopped	
100 hr.	1	A		
250 hr.	1	A		

GROUP II 160 HR. TEMP. STEPS

TEST STEP A	MFR A		MFR B	
	QTY.	NOTE	QTY.	NOTE
75°C	0	-	0	-
100°C	0	-	1	A
125°C	0	-	1	B
150°C	0	-	1	A
175°C	0	-	2	A
200°C	0	-	1	B
225°C	1	A	3	A
250°C	3	A	Job Stopped	
275°C	5	A		
300°C	Job Stopped			

GROUP III 16 HR. TEMP. STEPS

TEST STEP A	MFR A		MFR B	
	QTY.	NOTE	QTY.	NOTE
150°C	0	-	0	-
175°C	0	-	0	-
200°C	0	-	2	A
225°C	1	A	0	-
250°C	3	A	0	-
275°C	5	A	2	A
300°C	Job Stopped		Job Stopped	

MFR "A" = Siemens

MFR "B" = Motorola

NOTES:

(A) $B_V < 3.04V$ (B) $B_V > 10.08V$

(C) Shorted (verified by Failure Analysis)



TABLE 9 STEP STRESS PARAMETRIC FAILURE SUMMARY JAN TX1N4570A

GROUP I POWER STRESS				GROUP II 160 HR. TEMP. STEPS				GROUP III 16 HR. TEMP. STEPS			
TEST STEP	MFR A		MFR B	TEST STEP A	MFR A		MFR B	TEST STEP A	MFR A		MFR B
	QTY.	NOTE			QTY.	NOTE			QTY.	NOTE	
50% 50 hr.	0	-	-	75° C	0	-	B	150° C	0	-	-
100 hr.	0	-	-	100° C	0	-	-	175° C	0	-	-
100 hr.	0	-	-	125° C	0	-	-	200° C	0	-	B
250 hr.	0	-	-	150° C	0	-	-	225° C	0	-	G
100% 50 hr.	1	A	-	175° C	0	-	-	250° C	0	-	B
100 hr.	0	-	-	200° C	1	D	-	275° C	0	-	H
100 hr.	0	-	-	225° C	1	E	F	300° C	Job Stopped	Job Stopped	
250 hr.	0	-	-	250° C	0	-	Job Stopped				
125% 10 hr.	0	-	-	275° C	0	-					
15 hr.	0	-	-	300° C	Job Stopped						
25 hr.	0	-	-								
100 hr.	0	-	-								
100 hr.	0	-	-								
250 hr.	0	-	-								
150% 10 hr.	0	-	-								
15 hr.	0	-	-								
25 hr.	0	-	-								
100 hr.	0	-	-								
100 hr.	0	-	-								
250 hr.	0	-	-								
175% 10 hr.	0	-	-								
15 hr.	0	-	-								
25 hr.	0	-	-								
100 hr.	0	-	-								
100 hr.	0	-	-								
250 hr.	0	-	-								
100 hr.	1	B	-								
100 hr.	1	B	-								
250 hr.	0	-	-								

NOTES:

(A) S/N 9703 part missing from lot.

(B) B_v minimum limit failure.

(C) B_v maximum limit failure.

(D) S/N 9723 removed from testing as a MIL-STD-1900 limit failure.

(E) S/N 9722 removed from testing as a MIL-STD-19500 limit failure.

(F) S/N 9767 removed from testing as a MIL-STD-19500 limit failure.

(G) S/N 9778 and 9779 removed from testing as a MIL-STD-19500 limit failures.

(H) S/N 9786 and 9793 removed from testing as a MIL-STD-19500 limit failures.

MFR "A" = Siemens

MFR "B" = Motorola



JANTX1N4570A

APPENDIX

FAILURE ANALYSIS

Temperature Stress I



FAILURE ANALYSIS - DIODES
MSFC STEP-STRESS TEST

JANTX1N4570A

(Temperature Stress I)

Date 27 November 1978

J/N 2CN242-37B P/N 1N4570A MFR Siemens

End points:
3.04-10.08V

S/N	PIV -volts- @ 1.0mA	I_R @ ____ V.dc	V_f @ ____ dc			Initial Rej. @ Test Seq. No.:		Initial Rej. for:
9714	11.5V					15 (225°C 1120 Hrs.Tot)		B_V
9716	short					15 (225°C 1120Hrs.Tot)		B_V
9720	11.2V					15 (225°C 1120Hrs.Tot)		B_V

INTERNAL VISUAL INSPECTION:

S/N 9714 has no significant visual defects.

S/N 9716 has cracked glass which dropped out when touched leaving an open hole (see Figure A-1).

S/N 9720 - essentially all the topside die bonding material has crept up the internal lead leaving the die top metal joint depleted.

These diodes are constructed with two stacked silicon dice in series. The die nearer to the cathode lead is square and the anode die is round.

* h_{FE} trace present. Cannot meet stated test conditions. (Leaky)

** h_{FE} trace very leaky.

D = drift H = hysteresis Inv = inversion R = resistive S = soft Uns = unstable



FAILURE ANALYSIS - DIODES

JANTX1N4570A

MSFC STEP-STRESS TEST

(Temperature Stress I)

Date 27 November 1978

J/N 2CN242-37B P/N 1N4570A MFR Motorola

End points:
3.04-10.08V

S/N	PIV -volts- @ 1.0mA	I_r @ _____ V.dc	V_f @ _____ dc			Initial Rej. @ Test Seq. No.:		Initial Rej. for:
9763	11 & 25V (S) @ 200uA					07 (125°C 480Hrs.Tot)		B_v
9771	17 & 25V(S) @ 60uA					05 (100°C 320Hrs.Tot)		B_v
9774	15 & 25V(S) @ 120uA					09 (150°C 640Hrs.Tot)		B_v

INTERNAL VISUAL INSPECTION:

All three samples exhibited metal flow up the internal lead which left the die top metal joint depleted (see Figure A-2).

There were no other significant visual defects.

* h_{FE} trace present. Cannot meet stated test conditions. (Leaky)

** h_{FE} trace very leaky.

D = drift H = hysteresis Inv = inversion R = resistive S = soft Uns = unstable

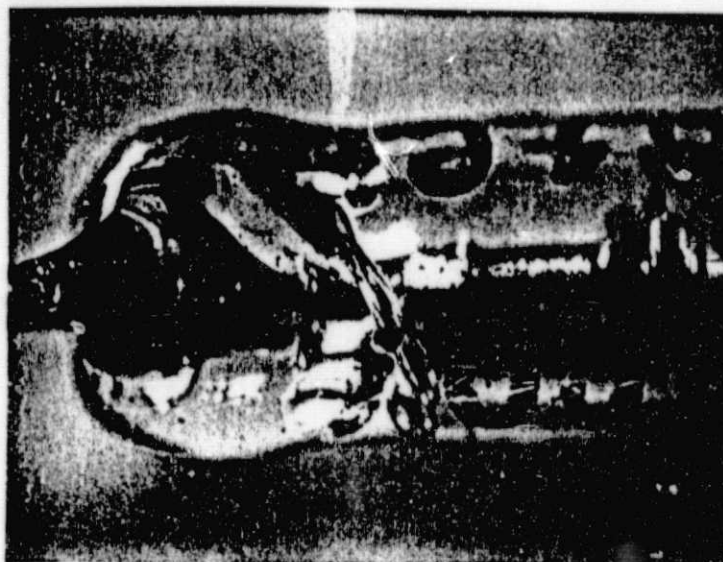


FIGURE A-1
S/N 9716, Cracked Glass at
Glass-to-Metal Seal, Siemens 16X.

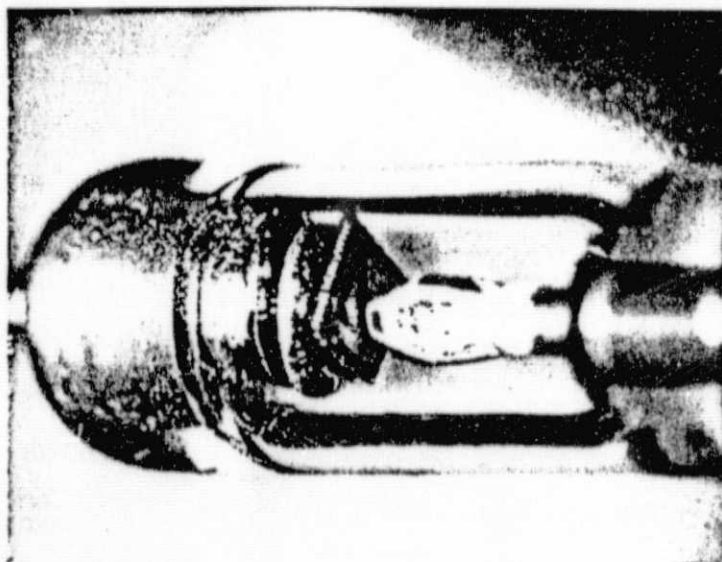


FIGURE A-2
S/N 9774, Typical Motorola sample
showing solder climb up the internal
internal lead, thus leaving the top die
contact. Motorola 16X.



CONCLUSIONS

Siemens

Siemens sample number 9716 has bulk silicon damage resulting from normal early burn-in failure at a crystal defect site.

The two other Siemens devices have good hard breakdowns which do not change when measured at any current between one microamp and one milliamp. The fact that they met their breakdown limits at earlier measurement points suggests that there were junction defects present originally which caused the devices to operate at a lower voltage. These atomic level defects were "burned out" of the dice, thus allowing the true breakdowns to appear.

Motorola

The Motorola samples each contain two dice in series, presumably as a means of tailoring the breakdown voltage to the desired value. When measured at low and high currents (1.0uA and 1.0mA) two distinct breakdowns can be seen. However, both breakdowns are seriously above the allowable range on all these samples.

As with the Siemens devices above, the change to higher breakdowns after some hundreds of hours of stress can be explained by the burning out of diffusion spikes from the junction, thus allowing the true breakdowns to appear.

It may be noted that there was no evidence of any surface problem on any of these samples, including Siemens serial number 9716, which had cracked glass.